REMARKS

Reconsideration and withdrawal of the objections and rejections set forth in the above-mentioned Official Action in view of the foregoing amendments and the following remarks are respectfully requested.

Claims 1-5 and 7-11 are now pending in the application, with Claims 1 and 11 being independent. Claim 6 has been cancelled without prejudice. Claims 1-5 and 7-11 have been amended herein.

The drawings were objected to for not including a reference numeral mentioned in the specification and for including a reference numeral that is not mentioned in the specification. In response, throughout the specification, each occurrence of detector "33" has been changed to --32--. Favorable consideration and withdrawal of the objection to the drawings are requested.

Claims 1-10 were objected to for minor informalities. These informalities have been resolved in the specification and withdrawal of the objection to the claims is requested.

Claims 2-5 were rejected under 35 U.S.C. § 112, second paragraph as allegedly being indefinite. Without conceding the propriety of the rejection, Applicants have reworded the language questioned by the Examiner. Reconsideration and withdrawal of the § 112 rejection are also requested.

Claims 1, 2, 4, 8, 9 and 11 were rejected under 35 U.S.C. § 102 as being anticipated by U.S. Patent No. 5,397,192 (Khormaee). Claims 1-4 and 6-11 were rejected under § 102 as being anticipated by U.S. Patent No. 5,448,269 (Beauchamp, et al.). Claims

1, 2, 5, 6 and 8-11 were rejected under § 102 as being anticipated by U.S. Patent No. 6,227,644 (Perner). These rejections are respectfully traversed.

As is recited in independent Claim 1, the present invention relates to a printing apparatus for printing an image on a printing medium while relatively moving at least one of a printing head provided with an array of a plurality of printing elements and the printing medium. The apparatus includes a carriage, detection means and control means. The carriage mounts the printing head, and is movable relative to the printing medium in a scanning direction crossing the array of the plurality of printing elements. The detection means is mounted on the carriage and detects a printing position of an array of printed pixels corresponding to the array of the plurality of printing elements. The control means controls drive timing of the plurality of printing elements according to detection results of the detection means so as to make printing positions of the printed pixels close to a predetermined center position.

As is recited in independent Claim 11, the present invention relates to a printing method for printing an image on a printing medium while relatively moving at least one of a printing head provided with an array of a plurality of printing elements and the printing medium. The method includes the step of relatively moving at least one of the printing head and the printing medium in a scanning direction crossing the array of the printing elements so that an array of printed pixels corresponding to the array of the printing elements is printed on the printing medium. The method also includes the steps of detecting printing positions of the array of printed pixels, and controlling drive timing of the plurality of printing elements according to detection results of the printing positions so

as to make printing positions of subsequently printed pixels close to a predetermined center position.

The claimed arrangement and method can overcome the problems in prior apparatuses. Because of dimensional errors of a printhead and mounting errors of the printhead onto a carriage, an array of ink ejection openings (40a to 40l) can be inclined as shown in Figure 3A. An image printed by such a printhead can result in dots (41a to 41l) being printed as shown in Figure 3B. With the above arrangement and method, however, printing positions of the printed dots can be detected by detection elements and according to the detection result, drive timings of the printing elements in the printing head can be controlled. As a result, printed dots (41a to 41l) can be printed as shown in Figure 3C, so that the deviation amount of the printed dots is smaller (i.e., close to center C).

Khormaee relates to a shuttle-type printing method and system in which a printhead and an optical sensor are disposed on a carriage. The carriage is moved so that the optical sensor is positioned over a platen demarcation, so that the optical sensor can generate a position signal. This is used to determine the absolute position of the carriage relative to the platen.

Beauchamp, et al. relates to an ink jet printing system in which a printhead prints a test pattern and a sensor optically senses the test pattern.

Perner relates to an ink jet printer in which the printhead includes an imaging sensor.

However, Applicants respectfully submit that Khormaee, Beauchamp, et al. and Perner fail to disclose or suggest at least the detection means and control means recited

in independent Claim 1 and the detecting and controlling steps recited in independent Claim 11. That is, these citations fail to disclose or suggest detecting printing positions of an array of printed pixels and controlling drive timing of a plurality of printing elements according to detection results so as to make printing positions of subsequently printed pixels close to a predetermined center position, as is recited in independent Claims 1 and 11.

Thus, Khormaee, Beauchamp, et al. and Perner fail to disclose or suggest important features of the present invention recited in the independent claims.

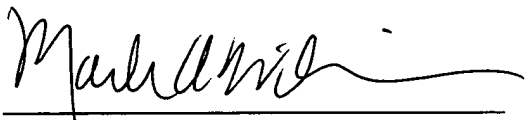
Thus, independent Claims 1 and 11 are patentable over the citations of record. Reconsideration and withdrawal of the § 102 rejections are respectfully requested.

For the foregoing reasons, Applicants respectfully submit that the present invention is patentably defined by independent Claims 1 and 11. Dependent Claims 2-5 and 7-10 are also allowable, in their own right, for defining features of the present invention in addition to those recited in their respective independent claims. Individual consideration of the dependent claims is requested.

Applicants submit that the present application is in condition for allowance. Favorable reconsideration, withdrawal of the objections and rejections set forth in the above-noted Office Action, and an early Notice of Allowance are requested.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

The paragraph starting at page 3, line 4 has been amended as follows.

In the present invention, detection means is used. The [detecting] detection means is capable of detecting the image printed on the printing medium by moving along with the printing head relative to the printing medium. The printing head is controlled according to the detection result of the detection means. To be more concrete, the driving of the plurality of printing elements in the printing head [are] is controlled. Actual printing result information by the plurality of printing elements in the printing head is fed back, thereby these printing elements are controlled according to the actual situation. As a result, the image can be printed stably and with high accuracy by avoiding effects of a dimensional error printing characteristics specific to the printing head and a mounting error of the printing head.

The paragraph starting at page 3, line 19 has been amended as follows.

Further, by providing the detection means and replaceably mounting the printing head to the carriage of a serial-type printing apparatus, control contents for the printing head can be corrected. Thereby, particularly, [it is avoided that] the effects of the printing [characteristic] characteristics of each of the replaceable printing [head] heads and mounting error due to attachment and detachment of the printing head are avoided. As a

result, stable printing can be achieved without variation [with] of printing characteristics specific to the printing head.

The paragraph starting at page 4, line 20 has been amended as follows.

Further, by the detection means provided commonly for the plurality of printing heads, an image printed by each of the plurality of printing heads can be detected. Thereby, the actual [situation] situations of the plurality of printing heads are efficiently detected, and the detection [result] results can be utilized in controlling these printing heads.

The paragraph starting at page 4, line 26 has been amended as follows.

Yet further, as the detection means, [it can be used that has] a light source for emitting light and a photoelectric conversion element for receiving reflected light from the printing medium can be used. Yet further, as the printing head, it is possible to use an ink-jet printing head provided with a plurality of ink ejectable printing elements.

The paragraph starting at page 6, line 3 has been amended as follows.

DETAILED DESCRIPTION OF THE PREFERRED [EMBODIMENT] EMBODIMENTS

In the following, [an embodiment] embodiments of the present invention will be described with reference to the drawings. The present embodiment is an application example [as] of an ink-jet printing apparatus and ink-jet printing method for forming an image on a printing medium.

The paragraph starting at page 6, line 10 has been amended as follows.

Fig. 1 is a perspective diagram of an ink-jet printing apparatus 1, which [is representing the] represents features of the present invention. In Fig. 1, numeral 2 denotes an ink-jet printing head provided with a plurality of nozzles constituting a plurality of printing elements. The respective nozzles are provided so as to eject an ink [to] in the [down] downward direction in the figure. As the ink ejection method, any of a method using a piezoelectric element and a bubble-jet method for ejecting ink by a bubble in the ink generated by [a] thermal energy and the like may be employed. In the case of the bubble-jet method, by an electrothermal converter provided in the nozzle communicating with the ink ejection opening, [a] thermal energy utilized as [an] ink ejection energy is generated. That is, in association with bubble generation of ink by the thermal energy, an ink droplet can be ejected from the ink ejection opening. Numeral 3 is a carriage [possible to mount] for mounting the printing head 2 and which carriage is connected to a timing belt 9. The timing belt 9 is [put up] mounted between a drive pulley 8 and a guide pulley (not shown). By rotating the drive pulley 8 by a carriage motor 7, the carriage 3 is reciprocally moved in the primary scanning direction of arrow A through the timing belt 9. The

carriage 3, by being slidingly moved on a slide shaft 4 and a slide plate 5 fixed between chassis 6a and 6b, with [the] a regulated posture, is reciprocally moved [at the opposite position] to a position opposite to a paper 30 as a printing medium. The paper 30 is stacked in a paper feed unit 10, and, as necessary, is fed onto a platen by a paper feed roller (not shown), and [printed on] a portion [of which onto] thereof on the platen is formed with an image by the printing head 2. That is, by repeating a printing operation and a feeding operation, images are successively printed on the paper 30. In the printing operation, the printing head 2 ejects an ink droplet while moving in the primary scanning direction. In the feeding operation, the paper 30 is fed a predetermined amount in a secondary scanning direction by arrow B by a transportation roller 11 and a paper discharge roller 13.

The paragraph starting at page 7, line 20 has been amended as follows.

To the transportation roller 11, rotation of the transportation motor (not shown) appropriately reduced by a gear train 14 is transmitted. Numeral 12 is a pinch roller which is disposed at a position pressing against the transportation roller 11. The paper 30 is pressed between the transportation roller 11 and the pinch roller 12, so that transportation force is surely transmitted. A transmission roller 34 rotates the paper discharge roller 13 slightly [accelerating as compared with] faster than the transportation roller 11. An area between the transportation roller 11 and the paper discharge roller 13 is a printing area, which is set as a larger area than a maximum printing width by all nozzles

of the printing head 2, thereby in the printing area, flatness of the paper 30 is secured. The right side position in Fig. 1 is a stand-by position of the printing head 2, at which a recovery operation for recovering the ink ejection condition of the nozzle is performed. Numeral [33] 32 is a printing condition detector as detection means mounted on the carriage 3, which, as will be described later, is provided with a plurality of detection elements.

The paragraph starting at page 8, line 14 has been amended as follows.

Fig. 2 is an enlarged perspective diagram showing [part] a portion for explaining the construction of the printing condition detector [33] 32.

The paragraph starting at page 8, line 17 has been amended as follows.

In Fig. 2, numeral 26 is a light source unit for irradiating light to an image printing part on the paper 30. Reflected light from the image printing part on the paper 30 is focused by a focusing lens 27 disposed vertically above the paper 30, on a detection element (not shown) of a reading sensor 29. The reading sensor 29 and the focusing lens 27 are integrated by a lens holder 28, [and] which is incorporated with the carriage 3 after position adjusting. The reading sensor 29 is mounted to the lens holder 28 through a flexible cable 31, and transmits a read signal of reflected light from the image printing part on the paper 30 to an image processing circuit 30 on the flexible cable 31. The image

processing circuit 30 transmits a processing result of the read signal through a flexible cable 24 to a processing circuit of a printing apparatus main body. Numeral 19 is a bearing [penetrated] in sliding contact with the slide shaft 4, and 26 is a pressing member for pressing the light source unit 25 to a predetermined position. Further, numerals 20 and 23 are slide members slidably guided by the apparatus main body side guide member including the slide plate 5. Still further, numeral 18 is a sensor for detecting a moving position of the carriage 3.

The paragraph starting at page 9, line 13 has been amended as follows.

The printing head 2 can be mounted between a contact portion 3a and a head holder 21 of the carriage 3. By rotation of a lever 22, a contact portion 2a (see Fig. 1) of the printing head 2 is pressed against the contact portion 3a of the carriage 3 so that these components electrically [conduct to] contact each other. The printing signal is inputted from the flexible cable 24 to the printing head 2 through the contact portion 3a and the contact portion 2a, and the printing head 2 ejects ink [droplet] droplets according to the printing signal.

The paragraph starting at page 9, line 23 has been amended as follows.

Fig. 3A is a diagram for explaining the relationship among detection devices 50a and 50b of the printing condition detector [33] 32 fixed in a predetermined position on

the carriage 3 and ink ejection openings 40a to 40l of the printing head 2 replaceably mounted on the carriage 3. [This] Fig. 3A is a diagram of the detection devices 50a and 50b and the ink ejection openings 40a to 40l when viewed from vertically above the surface of the paper 30. In the case of the present embodiment, when the carriage 3 scans in the direction of the arrow in the figure, the printing head 2 performs the printing operation. The array of the ink ejection openings 40a to 40l should essentially be along a design center C perpendicularly crossing with the primary scanning direction of the arrow in the figure. However, because of dimensional error of the printing head 2 and a mounting error of the printing head 2 to the carriage 3, the array of the ink ejection openings 40a to 40l (nozzle array) inclines by an angle A relative to the design center C. Further, the printing condition detector [33] 32 of the present embodiment has two detection elements 50a and 50b, [and] which are mounted on [the] predetermined [position] positions of the carriage 3 after position adjusting so that [which] they are arranged in a direction perpendicular to the primary scanning direction of the arrow in the figure, that is, positioned in the vertical direction in Fig. 3A. The array of the detection elements 50a and 50b in the vertical direction in Fig. 3A is set to be parallel to the design center C and to be in a position away from the center C by a predetermined distance M in the primary scanning direction. Further, the detection elements 50a and 50b are positioned away from each other by the same width as a maximum printing width W per scan of the printing head 2.

The paragraph starting at page 11, line 7 has been amended as follows.

Fig. 3B is a diagram for explaining printing dots (printing pixels) 41a to 41l formed by the printing head 2 mounted in the condition that the array of the ink ejection openings 40a to 40l is inclined relative to the direction perpendicularly crossing with the scanning direction of the printing head 2 as shown in Fig. 3A. In Fig. 3B, one ink droplet was ejected [one time] per scan from each of the [all] ink ejection openings 40a to 40l. Printing dots 41a to 41l are printing dots formed by ink droplets ejected from the respective ink ejection openings 40a to 40l. Inclination of the array of the printing dots 41a to 41l corresponds to inclination of the ink ejection openings 40a to 40l. Symbol P in Fig. 3B represents a deviation amount between printing dots 41a and 41l in the primary scanning direction, that is, a deviation amount between the ink ejection openings 40a and 40l, which corresponds to a distance (L-S). During scanning of the carriage 3, the detection elements 50a and 50b immediately [detects] detect optically the printing dots 41a and 41l printed by the printing head 2. When a difference in detection time of these printing dots 41a and 41l is greater than a printing time for 1 dot as a minimum printing resolution, print timing of the image is adjusted. That is, as shown in Fig. 3B, a difference in detection time of the printing dots 41a and 41l is greater than 1 dot printing time as the minimum printing resolution, and it is judged [as] that adjustment of ink droplet ejection timing is necessary.

The paragraph starting at page 12, line 7 has been amended as follows.

In the present embodiment, among ink ejection openings at one end side and the other end side of the ink ejection opening array (nozzle array), one of a greater

deviation amount from the center C (in the present embodiment, the ink ejection opening 40l side) is determined as an adjustment subject side. Ink droplet ejection timing of the ink ejection openings (in the present embodiment, ink ejection openings 40i, 40j, 40k, and 40l) out of the tolerable deviation range of 1 dot as the minimum printing resolution [are] is shifted by 1 dot printing time. The ink ejection openings out of the tolerable deviation range of 1 dot can be selected from the relation of the distance P determined from the detection time difference of the detection elements 50a and 50b, the printing width W, and the arrangement position of the ink ejection openings.

The paragraph starting at page 13, line 2 has been amended as follows.

Further, a control system of the printing apparatus according to the present invention can be a system configuration including a CPU, ROM and RAM. In this case, the CPU executes a processing for the above-described ejection timing adjustment according to a program stored in the ROM. For example, the CPU first determines whether or not a difference in detection time of printing dots 41a and 41l by the detection elements 50a and 50b is greater than [tome] the time for 1 dot as the minimum printing resolution. When the detection time is greater than 1 dot printing time, it is determined that print timing adjustment is necessary, and an ink ejection opening to be subjected to ejection timing adjustment [subject] is selected as described above. In the selection, a data table can be used. Then, a control signal is sent to a control circuit of the printing head 2 so that ejection timing of an ink droplet from the selected ink ejection opening is shifted.

The RAM can be used as a work area for the processing of the CPU. Further, under the control of the CPU, through a driver, the printing head 2, the carriage motor 7, and the transportation motor are controlled. Still further, it is also possible that under the control of the CPU, printing data is received from external devices such as a host apparatus, and an image is printed according to the printing data.

The paragraph starting at page 13, line 27 has been amended as follows.

In the above-described embodiment, a total of two detection elements are provided at positions corresponding to the ink ejection openings at both ends of the nozzle array. However, alternatively, detection elements may be provided so as to oppose all the ink ejection openings, in this case, the deviation amount can be corrected independently for every ink ejection opening. Further, detection elements may be provided so that each one corresponds to every group of a plurality of ink ejection openings.

The paragraph starting at page 15, line 5 has been amended as follows.

Yet further, the present invention can also be applied to printing [head] heads provided with various printing [element] elements such as thermal transfer type heads and the like, in addition to the printing head provided with the ink-jet printing element.

The paragraph starting at page 15, line 10 has been amended as follows.

The present invention has been described in detail with respect to preferred embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader [aspect] aspects, and it is the intention, therefore, [in] that the [apparent] appended claims [to] cover all such changes and modifications as fall within the true spirit of the invention.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

1. (Amended) A printing apparatus for printing an image on a printing medium while relatively moving at least one of a printing head provided with an array of a plurality of printing elements and the printing medium, [characterized by] said apparatus comprising:

a carriage mounting said printing head, and movable relative to the printing medium in a scanning direction crossing said array of said plurality of printing elements;

detection means [capable of moving along with said printing head relative to said printing medium] mounted on said carriage for detecting [image printed on said printing medium] printing positions of an array of printed pixels corresponding to said array of said plurality of printing elements; and

control means for controlling [said printing head according to a detection result of said detection means] drive timing of said plurality of printing elements according to detection results of said detection means so as to make printing positions of subsequently printed pixels close to a predetermined center position.

2. (Amended) The printing apparatus as claimed in Claim 1, wherein said [printing head and said detection means can be mounted on a carriage relatively moving to said printing medium] control means controls the drive timing of said plurality of printing elements so as to make deviation amounts of the printed pixels in the scanning direction to be equal or less than one of the printed pixels in size.

3. (Amended) The printing apparatus as claimed in Claim [2] 1, wherein said printing head is replaceably mounted [to] on said carriage, and said detection means is mounted fixedly on a predetermined position of said carriage.

4. (Amended) The printing apparatus as claimed in Claim [2] 1, further comprising:

moving means for moving said carriage in a primary scanning direction; and

transportation means for transporting [said] the printing medium in a secondary scanning direction crossing [with said] the primary scanning direction.

5. (Amended) The printing apparatus as claimed in Claim [2] 1, wherein said plurality of printing elements of said printing head are arranged in a direction crossing [with said primary] the scanning direction when said printing head is mounted on said carriage; and

said detection means has a plurality of detection elements arranged [in a] at predetermined [position] positions of said carriage so as to be arranged along [by] a specified direction crossing [with said primary] the scanning direction.

7. (Amended) The printing apparatus as claimed in Claim 1, wherein said detection means is movable with a plurality of printing heads, and is provided commonly to said plurality of printing heads so as to detect images printed by [said] the respective printing heads of said plurality of printing heads; and

said control means controls said plurality of printing heads according to detection results of said detection means.

8. (Amended) The printing apparatus as claimed in Claim 1, wherein said detection means [has] comprises a light source for irradiating light to [said] the printing medium and a photoelectric conversion device for receiving reflected light from [said] the printing medium.

9. (Amended) The printing apparatus as claimed in Claim 1, wherein said printing head is an ink-jet printing head provided with [a] said plurality of printing elements, which are capable of ejecting ink.

10. (Amended) The printing apparatus as claimed in Claim 9, wherein said printing elements of said ink-jet printing head [have] comprise electrothermal converters for generating thermal energy as ink ejection energy.

11. (Amended) A printing method for printing an image on a printing medium while relatively moving at least one of a printing head provided with an array of a plurality of printing elements and the printing medium, [characterized in that] comprising the steps of:

[an image printed on said printing medium is detected by detection means moving along with said printing head relative to said printing medium; and

said printing head is controlled according to a detection result of said detection means]

relatively moving at least one of the printing head and the printing medium in a scanning direction crossing the array of the printing elements so that an array of printed pixels corresponding to the array of the printing elements is printed on the printing medium;

detecting printing positions of the array of printed pixels; and

controlling drive timing of the plurality of printing elements according to detection results of the printing positions so as to make printing positions of subsequently printed pixels close to a predetermined center position.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE ABSTRACT

The present invention is to provide a printing apparatus and printing method capable of stably printing an image with high accuracy by avoiding effects of a dimensional error and printing characteristics specific to a printing head and a mounting error of the printing head. For this purpose, a printing condition detector [as detection means] is mounted [to] on a carriage moving in a primary scanning direction, and a printing head is mounted replaceably [to] on the carriage. An image printed on a printing medium by the printing head is detected by the printing condition detector, and the printing head is controlled according to the detection result.

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